

Short Course: **Centrifugal Compressors 201**

Course Overview:

This course supplements the Centrifugal Compressor 101 course by covering in greater detail four key areas related to centrifugal compressors as described below. It is intended for those who attended the 101 and wish to learn more about these topics. The course is also structured for those practicing rotating machinery engineers that have a basic understanding of the topics covered in Centrifugal Compressors 101 but wish to further their understanding in these key areas.

I. Aerodynamics – Jim Sorokes – Siemens / James Hardin - Elliott

1. Compressor Design and Analysis (*Sorokes*)
 - a. Nomenclature review (Compressor 101 refresher)
 - b. Analysis & design methods
 - c. Design tools (i.e., 1D, 2D, 3D)
 - i. Capabilities / Limitations / Assessment Criteria
2. CFD and its Role (*Hardin*)
3. Performance Issues (*Sorokes*)
 - a. Causes & Trends
 - b. Trouble-shooting
 - c. Rotating stall
 - i. Most common types / sample cases

II. Rotordynamics – J. Jeffrey Moore - SwRI

1. Basic vibration theory
2. Modeling procedures
3. Bearing and seal analysis
4. API requirements
5. Instrumentation used
6. Sample vibration phenomena and case studies

III. Performance and Mechanical Testing – Nathan Keim - Siemens

1. API 617 and ASME PTC-10 requirements
2. Instrumentation and test methods
3. Test gas considerations
4. Sample testing pitfalls
5. Aerodynamic case studies

IV. Surge Control – Rainer Kurz (Solar)

1. What is Surge
2. Scenarios
3. Surge Control System Components
4. Surge Control System Layouts
5. Surge Control System Operation in different scenarios
6. Modeling of the Surge Control System
7. Surge control system design considerations
8. Integration of Compressor and Compression System



James M. "Jim" Sorokes is a Principal Engineer at Siemens with over 38 years of experience in the turbomachinery industry. Jim joined Dresser-Clark (now Dresser-Rand) after graduating from St. Bonaventure University in 1976. He spent 28 years in the Aerodynamics Group, became the Supervisor of Aerodynamics in 1984 and was promoted to Manager of Aero/Thermo Design Engineering in 2001. While in the Aerodynamics Group, his primary responsibilities included the development, design, and analysis of all aerodynamic components of centrifugal compressors. In 2004, Mr. Sorokes was named Manager of Development Engineering whereupon he became involved in all aspects of new product development and product upgrades. In 2005, he was promoted to principal engineer responsible for various projects related to compressor development and testing. He is also heavily involved in mentoring and training in the field of aerodynamic design, analysis, and testing.

Mr. Sorokes is a member of AIAA, ASME, and the ASME Turbomachinery Committee. He has authored or co-authored over forty technical papers and has instructed seminars and tutorials at Texas A&M and Dresser-Rand. He currently holds three U.S. patents and has five others patents pending. He was elected an ASME Fellow in 2008.



Jim Hardin is a Senior Engineer in the Advanced Technology department at Elliott Group, in Jeannette, Pennsylvania, where he performs computational fluid dynamics (CFD) and other aerodynamic analyses for turbines and compressors. Previous experience includes CFD and other analyses on shipboard propulsion and piping systems with Westinghouse Electric Corporation, and turbine design support and testing at Elliott Company. He has 32 years of engineering experience, mostly in aerodynamics and fluid systems.

Mr. Hardin received a B.S. degree (Mechanical Engineering, 1981) from Carnegie-Mellon University, and is a registered Professional Engineer in the State of Pennsylvania.



Dr. Jeffrey Moore is the manager of the Rotating Machinery Dynamics Section at Southwest Research Institute in San Antonio, TX. He holds a B.S., M.S., and Ph.D. in Mechanical Engineering from Texas A&M University. His professional experience over the last 20 years includes engineering and management responsibilities related to centrifugal compressors and gas turbines at Solar Turbines Inc. in San Diego, CA, Dresser-Rand in Olean, NY, and Southwest Research Institute in San Antonio, TX. His interests include advanced compression methods, rotordynamics, seals and bearings, computational fluid dynamics, finite element analysis, machine design, controls and aerodynamics. He has authored over 30 technical papers related to turbomachinery and has one patent issued and two pending. Dr. Moore has held the position of Oil and Gas Committee Chair for IGTI Turbo Expo and is the Associate Editor for the Journal of Tribology. He is also a member of the Turbomachinery Symposium Advisory Committee, the IFToMM International Rotordynamics Conference Committee, and the API

616 and 684 Task Forces.



Dr. Rainer Kurz is the Manager, Systems Analysis, at Solar Turbines Incorporated in San Diego, California. His organization is responsible for analyzing compression requirements, predicting compressor and gas turbine performance, for conducting application studies, and for field performance testing. Dr. Kurz attended the Universität der Bundeswehr in Hamburg, Germany, where he received the degree of a Dr.-Ing. in 1991. He has authored numerous publications about turbomachinery related topics, holds two patents, is an ASME fellow, and a member of the Turbomachinery Symposium Advisory Committee.



Nathan Keim presently is a Test Engineering Supervisor with Siemens, in Olean, New York. He is responsible for developing test methods to meet objectives for production testing and analytical aerodynamic performance analysis of centrifugal compressors. He has 10 years of engineering experience, all related to compressor operation and testing per industry guidelines.

Mr. Keim received a A.S. degree (Electro-Mechanical Engineering Tech, 2006) from Alfred State College, a B.S. degree (Electro-Mechanical Engineering Tech, 2010) from Rochester Institute of Technology, and is currently pursuing a Masters in Manufacturing Leadership from RIT. He is also a member of ASME.